514,422

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 November 2003 (27.11.2003)

PCT

(10) International Publication Number
WO 03/098620 A1

(51) International Patent Classification[7]: G11B 7/24

(21) International Application Number: PCT/KR03/00968

(22) International Filing Date: 16 May 2003 (16.05.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2002-141664 16 May 2002 (16.05.2002) JP

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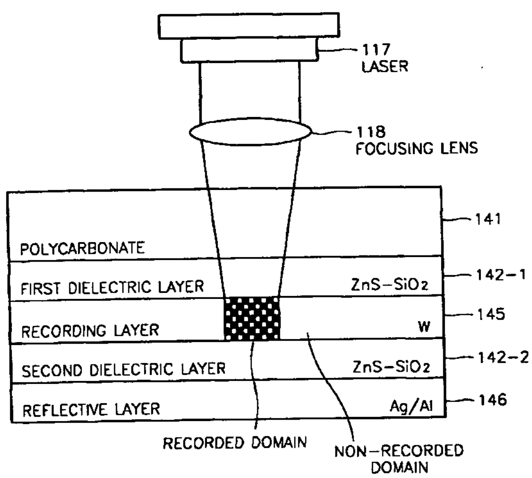
(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: RECORDING MEDIUM HAVING HIGH MELTING POINT RECORDING LAYER, INFORMATION RECORDING METHOD THEREOF, AND INFORMATION REPRODUCING APPARATUS AND METHOD THEREFOR



(57) Abstract: A simple-structured recording medium without a mask layer and information recording and reproducing methods, which resolve thermal stability related problems arising during reproduction, are provided. The recording medium includes a high melting point recording layer between first and second dielectric layers. The method of recording information on the recording medium involves irradiating a laser beam onto the recording medium to induce reaction and diffusion in the high melting point recording layer and the first and second dielectric layers. The method of reproducing information recorded on such a super-resolution near-field recording medium by the above method involves generating plasmon using crystalline particles of the high melting point recording layer and the first and second dielectric layers as a scatter source to reproduce information regardless of the diffraction limit.

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RECORDING MEDIUM HAVING HIGH MELTING POINT RECORDING LAYER, INFORMATION RECORDING METHOD THEREOF, AND INFORMATION REPRODUCING APPARATUS AND METHOD THEREFOR

Technical Field

The present invention relates to a recording medium, and more particularly, to a recording medium having a high melting point recording layer, an information recording method thereof, and an apparatus and method for reproducing information therefrom.

Background Art

Conventional recording media can be classified into magneto-optical recording media or phase change recording media. In magneto-optical recording media, such as mini disks (MDs), information is read by detecting the rotation of a straight polarized light reflected from a magnetic film depending on the magnetic force and the magnetization direction of the magnetic film. The rotation of the reflected light is known as the "Kerr Effect". In phase change recording media, such as digital versatile discs (DVDs), information is read based on the difference in reflectivity due to the different absorption coefficients of an optical constant between an amorphous recorded domain and a crystalline non-recorded domain of the recording medium.

Recently, many diversified methods of recording information using micro marks (pits), as in a phase change method, and reproducing information from the recording medium regardless of the diffraction limit have been suggested. The most interested one among these methods is a recording method using a super-resolution near-field structure, which is disclosed in Applied Physics Letters, Vol. 73, No.15, Oct. 1998, and Japanese Journal of Applied Physics, Vol. 39, Part I, No.2B, 2000, pp. 980- 981. A super-resolution near-field structure utilizes local surface plasmon generated in its special mask layer to reproduce information.

The super-resolution near-field structure is classified as an antimony (Sb) transmission type which has an antimony mask layer that becomes transparent by laser irradiation when reproducing information from the recording medium or as a silver oxide decomposition type which has a silver oxide (AgO_x) mask layer that decomposes into oxygen and silver, which acts as a scattering source inducing local plasmon.

FIG. 1 illustrates the structure of a recording medium using a conventional super-resolution near-field structure and the recording principle thereof. Such a structure as illustrated in FIG. 1 is referred to as "single-masked super-resolution near-field structure".

As shown in FIG. 1, the recording medium includes a second dielectric layer 112-2 made of dielectric materials, for example, ZnS-SiO_2, a recording layer 115 made of, for example, GeSbTe, a protective layer 114 made of dielectric materials, for example, ZnS-SiO_2 or SiN, a mask layer 113 made of, for example, Sb or AgO_x, a first dielectric layer 112-1 made of dielectric materials, for example, ZnS-SiO_2 or SiN, and a transparent polycarbonate layer 111, which are sequentially stacked upon one another. When the mask layer 113 is made of Sb, SiN is used for the protective layer 114 and the first dielectric layer 112-1. When the mask layer 113 is made of AgO_x, ZnS-SiO_2 is used for the protective layer 114 and the first dielectric layer 112-1. The protective layer 114 prevents reaction between the recording layer 115 and the mask layer 113 and becomes a place where acts upon a near field when reproducing information. When reproducing information, Sb of the mask layer 113 becomes transparent, and AgO_x of the mask layer 113 decomposes into oxygen and silver, which acts as a scattering source inducing local plasmon.

The recording medium is irradiated with a laser beam of about 10-15 mW emitted from a laser source 118 through a focusing lens 118 to heat the recording layer 115 above 600℃ so that a laser-irradiated domain of the recording layer 115 becomes amorphous and has a

smaller absorption coefficient k regardless of the change of refractive index n of an optical constant (n,k). In an irradiated domain of the Sb or AgO_x mask layer 113, the crystalline structure of Sb changes or the quasi-reversible AgO_x decomposes, generating a probe as a near-field structure pointing at a region of the recording layer 115. As a result, it is possible to reproduce information recorded on the recording medium as micro marks which are smaller in size than a diffraction limit of the laser used. Therefore, it becomes possible to reproduce information recorded in a high density recording medium using such a super-resolution near-field structure regardless of a diffraction limit of the laser used.

FIG. 2 illustrates the structure of a recording medium using another super-resolution near-field structure and the recording principle thereof. Such a structure as illustrated in FIG. 2 with two mask layers is referred to as "double-masked super-resolution near-field structure" and provides improved performance over a single-masked super-resolution near-field structure.

As shown in FIG. 2, the recording medium includes a second dielectric layer 112-2 made of dielectric materials, for example, $ZnS\text{-}SiO_2$, a second mask layer 123-2 made of, for example, Sb or AgO_x, a second protective layer 124-2 made of dielectric materials, for example, $ZnS\text{-}SiO_2$ or SiN, a recording layer 125 made of, for example, GeSbTe, a first protective layer 124-1 made of dielectric materials, $ZnS\text{-}SiO_2$ or SiN, a first mask layer 123-1 made of, Sb or AgO_x, a first dielectric layer 122-1 made of dielectric materials, for example, $ZnS\text{-}SiO_2$ or SiN, and a transparent polycarbonate layer 121, which are sequentially stacked upon one another. When the first and second mask layers 123-1 and 123-2 are made of Sb, SiN is used for the first and second protective layers 124-1 and 124-2 and the first and second dielectric layers 122-1 and 122-2. When the first and second mask layers 123-1 and 123-2 are made of AgO_x, $ZnS\text{-}SiO_2$ is used for the first and second protective layers 124-1 and 124-2 and the first and second dielectric layers 122-1

and 122-2. The second mask layer 123-2 is for generating surface plasmon at a side of the recording medium opposite to the laser irradiation side. The first and second protective layers 124-1 and 124-2 prevent reaction between the recording layer 125 and the respective first and second mask layers 123-1 and 123-2. Particularly, the first protective layer 124-1 acts as a near field when reproducing information. When reproducing information, Sb of the first and second mask layers 123-1 and 123-2 becomes transparent, and AgO_x of the first and second mask layers 123-1 and 123-2 decomposes into oxygen and silver, which acts as a scattering source inducing local plasmon.

The recording medium is irradiated with a laser beam of about 10-15 mW emitted from a laser source 117 through a focusing lens 118 to heat the recording layer 125 above 600℃ so that a laser-irradiated domain of the recording layer 125 becomes amorphous and has a smaller absorption coefficient k, regardless of the change of refractive index n of an optical constant (n,k). In an irradiated domain of the first and second mask layers 123-1 and 123-2, which are made of Sb or AgO_x, the crystalline structure of Sb changes or the quasi-reversible AgO_x decomposes, generating a probe as a near-field structure pointing at a region of the recording layer 125. As a result, it is possible to reproduce information recorded on the recording medium as micro marks which are smaller in size than a diffraction limit of the laser used. Therefore, it becomes possible to reproduce information recorded in a high density recording medium using such a super-resolution near-field structure regardless of a diffraction limit of the laser used.

However, in recording media having such a super-resolution near-field structure, since their mask layer and recording layer have similar transition temperatures, ensuring thermal stability to both of the mask layer and the recording layer during information reproduction is considered as being important. Possible solutions to this problem include dropping the transition temperature of the mask layer and raising

the transition temperature of the recording layer. However, it is not easy to induce a larger difference in transition temperature between the mask layer and the recording layer due to the nature of the materials composing the two layers.

Disclosure of the Invention

The present invention provides a simple-structured recording medium without a mask layer, the recording medium having a high melting point recording layer, an information recording method thereof, and an apparatus and method for reproducing information from the recording medium.

In accordance with an aspect of the present invention, as recited in claim 1, there is provided a recording medium comprising a high melting point recording layer between first and second dielectric layers.

In accordance with another aspect of the present invention, as recited in claim 7, there is provided a method of recording information on a recording medium having a high melting point recording layer between first and second dielectric layers, the method comprising irradiating a laser beam onto the recording medium to induce reaction and diffusion in the high melting point recording layer and the first and second dielectric layers.

In accordance with another aspect of the present invention, as recited in claim 13, there is provided an apparatus of reproducing information from a recording medium having a high melting point recording layer between first and second dielectric layers, the apparatus generating plasmon using crystalline particles of the high melting point recording layer and the first and second dielectric layers as a scattering source to reproduce information recorded in the recording layer using a super-resolution near-field structure regardless of the diffraction limit of the laser used.

In accordance with another aspect of the present invention, as recited in claim 19, there is provided a method of reproducing information

from a recording medium having a high melting point recording layer between first and second dielectric layers, the method comprising generating plasmon using crystalline particles of the high melting point recording layer and the first and second dielectric layers as a scattering source to reproduce information recorded in the recording layer using a super-resolution near-field structure regardless of the diffraction limit of the laser used.

According to specific embodiments of the above-described recording medium, information recording method, and information reproducing apparatus and method, the high melting point recording layer may be formed of tungsten (W), tantalum (Ta), a tungsten compound (W-x), or a tantalum compound (Ta-x). An additional reflective layer may be formed underneath the second dielectric layer, for example, using silver (Ag) or aluminum (Al).

Brief Description of the Drawings

FIG. 1 illustrates the structure of a conventional recording medium using a super-resolution near-field structure and the recording principle thereof;

FIG. 2 illustrates the structure of another conventional recording medium using super-resolution near-field structure and the recording principle thereof;

FIGS. 3A and 3B illustrate a recording medium according to an embodiment of the present invention and the recording principle thereof, and in particular, FIG. 3B is an enlarged view of a recorded domain of FIG. 3A;

FIGS. 4A and 4B illustrate a recording medium according to another embodiment of the present invention and the recording principle thereof, and in particular, FIG. 4B is an enlarged view of a recorded domain of FIG. 4A; and

FIG. 5 is a comparative graph of carrier to noise ratio (CNR) versus mark length for the recording media according to the present

invention and the conventional recording media.

Best mode for carrying out the Invention

The structure and operation of the present invention for resolving conventional problems will be described below in detail with reference to the appended drawings.

A recording medium according to an embodiment of the present invention and the recording principle are illustrated in FIGS. 3A and 3B. In particular, FIG. 3A is an enlarged view of a recorded domain of FIG. 3A.

Referring to FIG. 3A, a recording medium according to an embodiment of the present invention includes a second dielectric layer 132-2 made of dielectric materials, for example, $ZnS-SiO_2$, a high melting point recording layer 135 made of, for example, tungsten (W), tantalum (Ta), a tungsten compound (W-x), or a tantalum compound (Ta-x), a first dielectric layer 132-1 made of dielectric materials, for example, $ZnS-SiO_2$, and a transparent polycarbonate layer 131, which are sequentially stacked upon one another.

The recording medium is irradiated with a laser beam of about 11 mW and 405 nm wavelength emitted from a high-power laser source 117 through a focusing lens 118 to heat the recording layer 135 equal to or above 600℃ to induce reaction and diffusion in a laser-irradiated domain. W, Ta, W-x, or Ta-x in the recording layer 135 diffuse into the first and second dielectric layers 132-1 and 132-2, interact with $ZnS-SiO_2$ composing the two layers, and are crystallized.

FIG. 3B illustrates physical change in a laser-irradiated domain of the recording layer 135. As shown in FIG. 3B, the recording layer 135 has swollen at the laser-irradiated domain. A swollen portion of the recording layer 135 into the direction of the first dielectric layer 132-1 contributes to generating a near field when reproducing information. In addition, the crystalline particles of the recording layer 135 and the first

dielectric layer 132-1 formed by the reaction and diffusion by laser irradiation act as a scattering source generating surface plasmon when reproducing information. As a result, it is possible to reproduce information recorded on the recording medium as micro marks which are smaller in size than a diffraction limit of the laser used. Therefore, it becomes possible to reproduce information recorded in a high density recording medium using such a super-resolution near-field structure regardless of a diffraction limit of the laser used.

FIGS. 4A and 4B illustrates the structure of a recording medium according to another embodiment of the present invention and the recording principle thereof, and in particular, FIG. 4B is an enlarged view of a recorded domain of FIG. 4A.

Referring to FIG. 4A, a recording medium according to another embodiment of the present invention includes a reflective layer 146 made of, for example, silver (Ag) or aluminum (Al), a second dielectric layer 142-2 made of dielectric materials, for example, ZnS-SiO_2, a high melting point recording layer 145 made of, for example, tungsten (W), tantalum (Ta), a tungsten compound (W-x), or a tantalum compound (Ta-x), a first dielectric layer 142-1 made of dielectric materials, for example, ZnS-SiO_2, and a transparent polycarbonate layer 141, which are sequentially stacked upon one another.

The recording medium is irradiated with a laser beam of about 11 mW and 405 nm wavelength emitted from the high-power laser source 117 through the focusing lens 118 to heat the recording layer 145 equal to or above 600℃ to induce reaction and diffusion in a laser-irradiated domain. W, Ta, W-x, or Ta-x in the recording layer 145 diffuse into the first and second dielectric layers 142-1 and 142-2, interact with ZnS-SiO_2 composing the two layers, and are crystallized. The reflective layer 146, which is made of Ag or Al, is for inducing reaction and diffusion in the side of the recording layer 145 opposite to the laser irradiation side and the second dielectric layer 142-2, to a similar degree as in the side of

main of the recording layer 145 and the first dielectric layer 142-1 onto which the laser beam is directly irradiated, and for enhancing the effect of the reaction and diffusion in the directly laser-irradiated side.

FIG. 4B illustrates physical change in the laser-irradiated domain of the recording layer 145. As shown in FIG. 4B, the recording layer 145 has swollen at the laser-irradiated domain. A swollen portion of the recording layer 145 into the direction of the first dielectric layer 142-1 contributes to generating a near field when reproducing information. In addition, the crystalline particles of the recording layer 145, the first dielectric layer 142-1 and the second dielectric layer 142-2 formed by the reaction and diffusion by laser irradiation act as a scattering source generating surface plasmon when reproducing information. As a result, it is possible to reproduce information recorded on the recording medium as micro marks which are smaller in size than a diffraction limit of the laser used. Therefore, it becomes possible to reproduce information recorded in a high density recording medium using such a super-resolution near-field structure regardless of a diffraction limit of the laser used.

FIG. 5 is a comparative graph of carrier to signal ratio (CNR) versus mark length for the recording media according to the present invention and conventional recording media. Recording was performed on the recording media according to the present invention by inducing reaction and diffusion in their recording layer made of tungsten by irradiating a 405-nm laser at a power of 11 mW, through a focusing lens having a numerical aperture of 0.65. Reproduction was performed using a 405-nm laser at a power of 4 mW and a focusing lens having a numerical aperture of 0.65. For the conventional super-resolution near-field recording media of FIGS. 1 and 2 and a general phase change recording medium, recording and reproduction were performed using the same laser under the same conditions as for the recording media according to the present invention.

As is apparent from FIG. 5, the CNR with respect to varying mark

lengths is greatest for the super-resolution near-field recording medium of FIG. 4 according to the present invention and decreases in the order of the super-resolution near field recording medium of FIG. 3 according to the present invention, the conventional super-resolution near-field recording medium of FIG. 2, the conventional super-resolution near-field recording medium of FIG. 1, and a general phase change recording medium. This result indicates that high-density recording can be achieved especially with the super-resolution near-field structure of FIG. 4 according to the present invention, at a high CNR of about 45 dB for a mark length of 170 nm.

As described above, a recording medium with a high melting point recording layer and without a mask layer according to the present invention is suitable for high-density recording and reproduction, using the recording and reproducing methods and apparatus according to the present invention, without causing the thermal stability related problems arising when reproducing information from conventional super-resolution near-field recording media. The recording medium according to the present invention is cost low due to its simple structure.

What is claimed is:

1. A recording medium comprising a high melting point recording layer between first and second dielectric layers.

2. The recording medium of claim 1, wherein the high melting point recording layer is formed of tungsten.

3. The recording medium of claim 1, wherein the high melting point recording layer is formed of tantalum.

4. The recording medium of claim 1, wherein the high melting point recording layer is formed of a tungsten compound.

5. The recording medium of claim 1, wherein the high melting point recording layer is formed of a tantalum compound.

6. The recording medium of any one of claims 1 through 5, further comprising a reflective layer underneath the second dielectric layer.

7. A method of recording information on a recording medium having a high melting point recording layer between first and second dielectric layers, the method comprising irradiating a laser beam onto the recording medium to induce reaction and diffusion in the high melting point recording layer and the first and second dielectric layers.

8. The method of claim 7, wherein the high melting point recording layer is formed of tungsten.

9. The method of claim 7, wherein the high melting point recording layer is formed of tantalum.

10. The method of claim 7, wherein the high melting point recording layer is formed of a tungsten compound.

11. The method of claim 7, wherein the high melting point recording layer is formed of a tantalum compound.

12. The method of any one of claims 7 through 11, wherein the recording medium further comprises a reflective layer underneath the second dielectric layer.

13. An apparatus of reproducing information from a recording medium having a high melting point recording layer between first and second dielectric layers, the apparatus generating plasmon using crystalline particles of the high melting point recording layer and the first and second dielectric layers as a scattering source to reproduce information recorded in the recording layer using a super-resolution near-field structure regardless of the diffraction limit.

14. The apparatus of claim 13, wherein the high melting point recording layer is formed of tungsten.

15. The apparatus of claim 13, wherein the high melting point recording layer is formed of tantalum.

16. The apparatus of claim 13, wherein the high melting point recording layer is formed of a tungsten compound.

17. The apparatus of claim 7, wherein the high melting point recording layer is formed of a tantalum compound.

18. The apparatus of any one of claims 13 through 17, wherein the recording medium further comprises a reflective layer underneath the

second dielectric layer.

19. A method of reproducing information from a recording medium having a high melting point recording layer between first and second dielectric layers, the method comprising generating plasmon using crystalline particles of the high melting point recording layer and the first and second dielectric layers as a scattering source to reproduce information recorded in the recording layer using a super-resolution near-field structure regardless of the diffraction limit.

20. The method of claim 19, wherein the high melting point recording layer is formed of tungsten.

21. The method of claim 19, wherein the high melting point recording layer is formed of tantalum.

22. The method of claim 19, wherein the high melting point recording layer is formed of a tungsten compound.

23. The method of claim 19, wherein the high melting point recording layer is formed of a tantalum compound.

24. The method of any one of claims 19 through 23, wherein the recording medium further comprises a reflective layer underneath the second dielectric layer.

FIG. 1 (PRIOR ART)

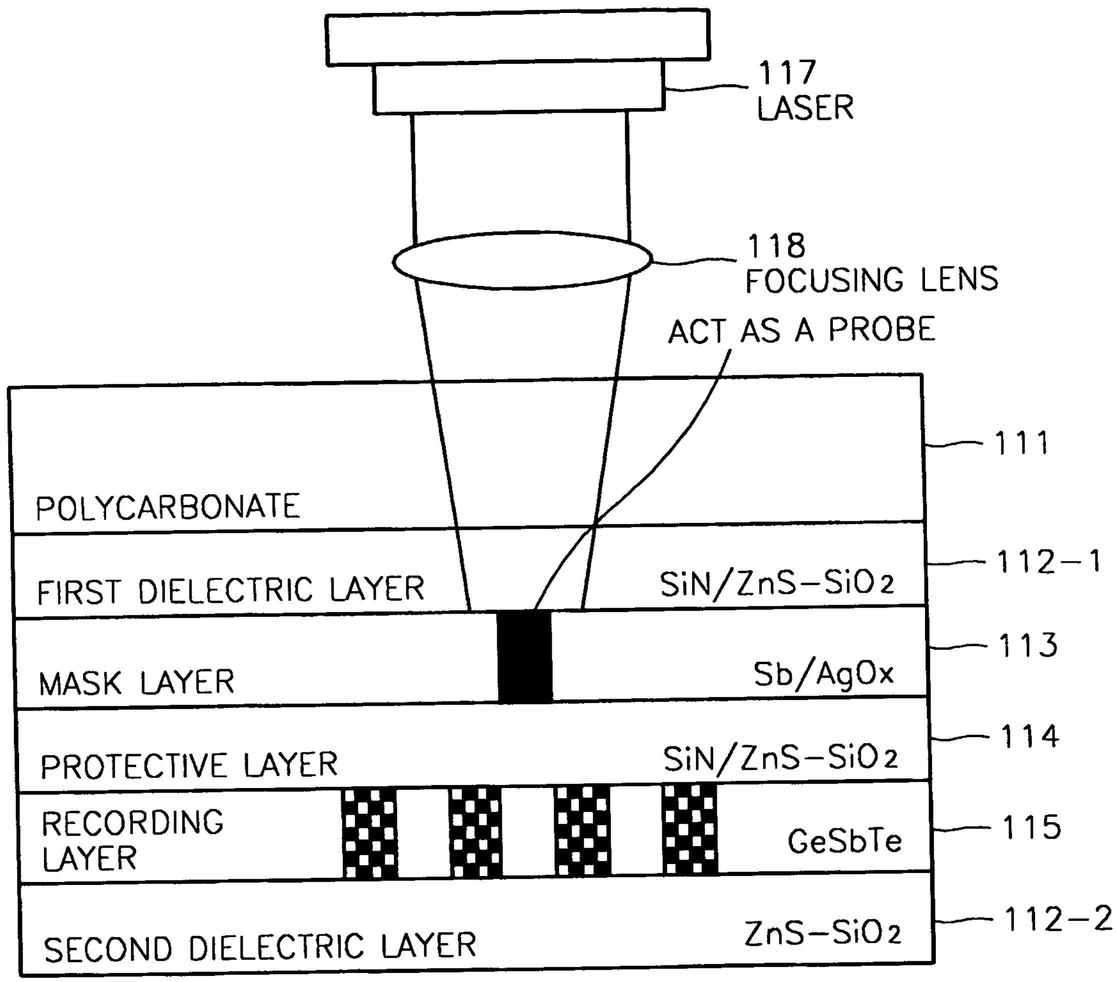


FIG. 2 (PRIOR ART)

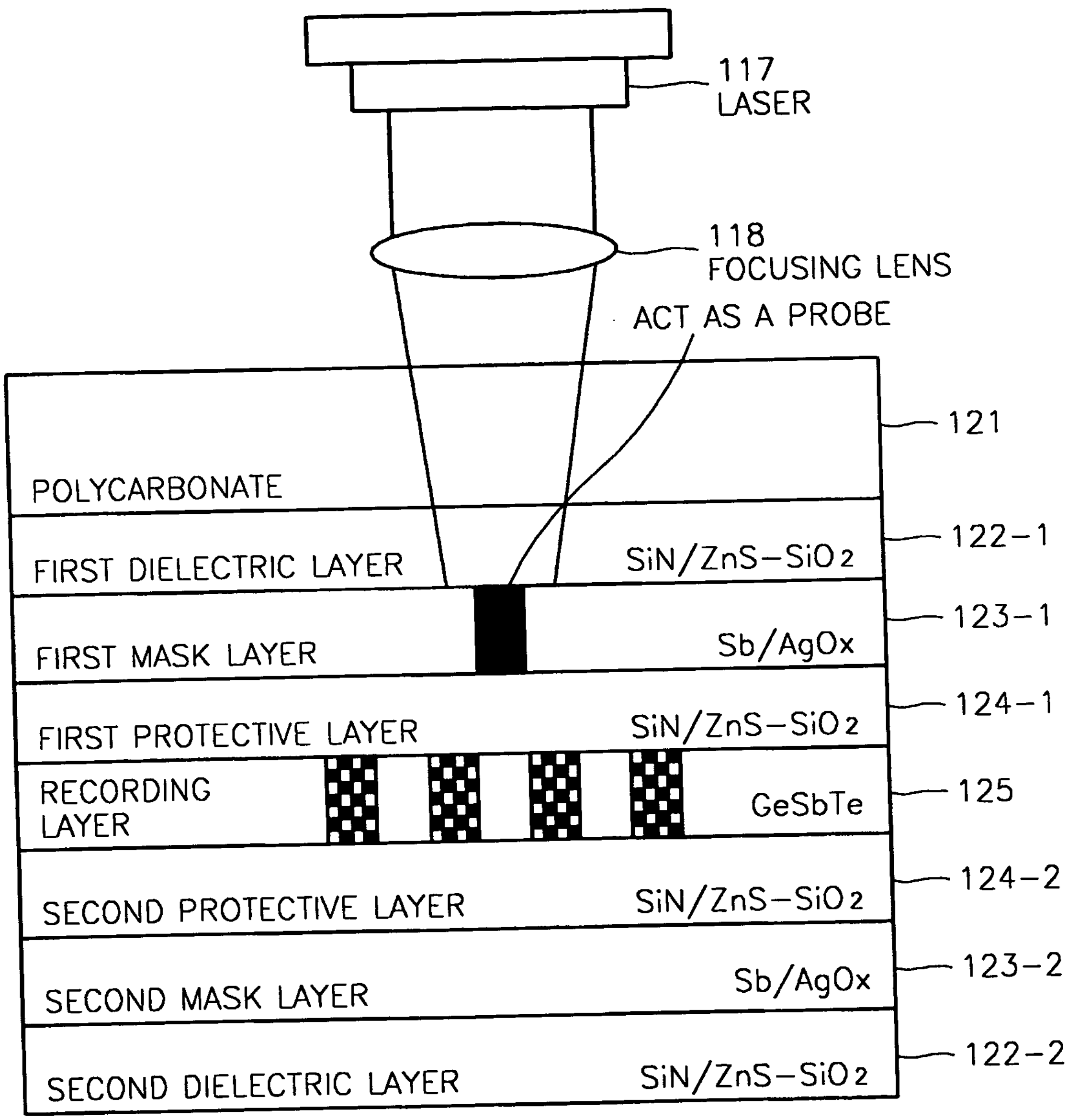


FIG. 3A

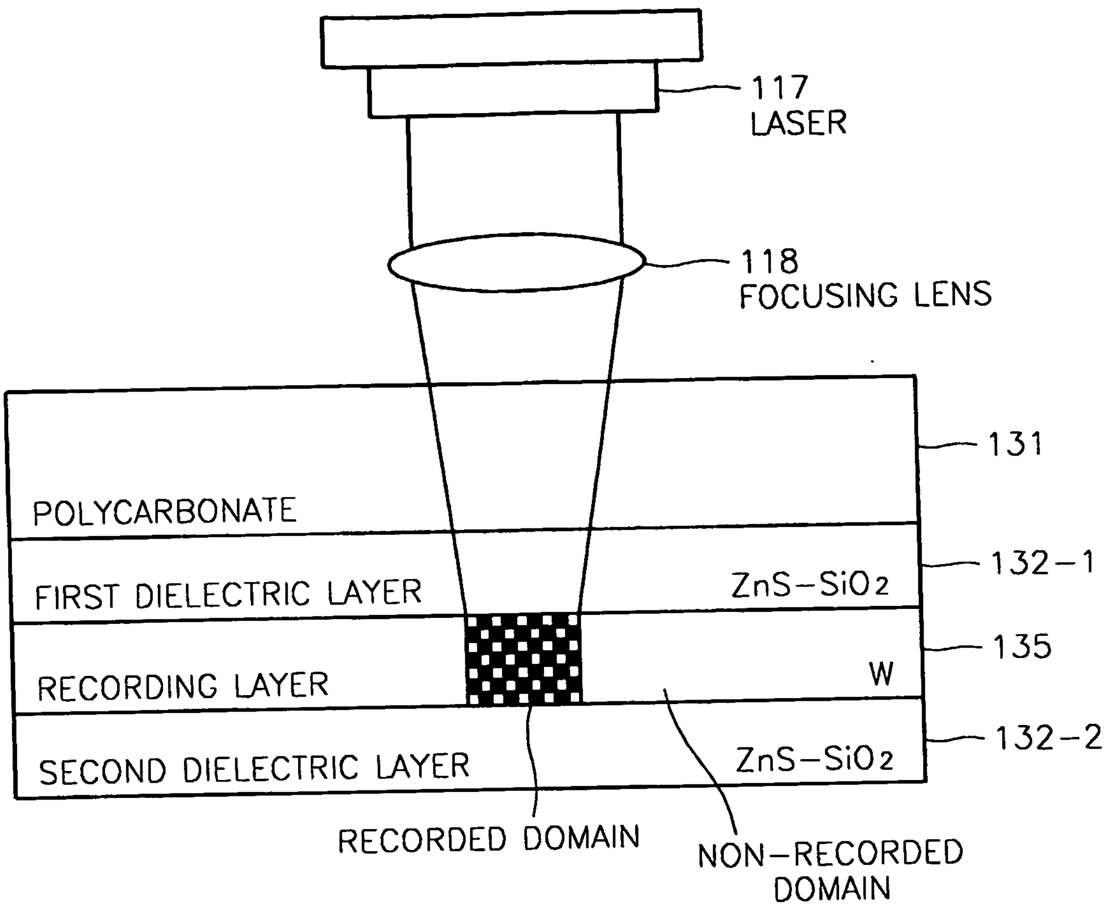

117
LASER
118
FOCUSING LENS
131
POLYCARBONATE
FIRST DIELECTRIC LAYER
ZnS-SiO2
132-1
RECORDING LAYER
W
135
SECOND DIELECTRIC LAYER
ZnS-SiO2
132-2
RECORDED DOMAIN
NON-RECORDED DOMAIN

FIG. 3B

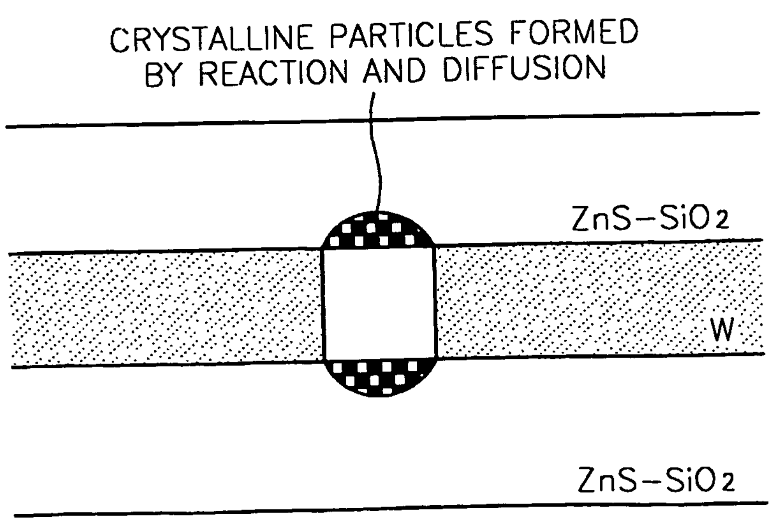

CRYSTALLINE PARTICLES FORMED BY REACTION AND DIFFUSION
ZnS-SiO2
W
ZnS-SiO2

FIG. 4A

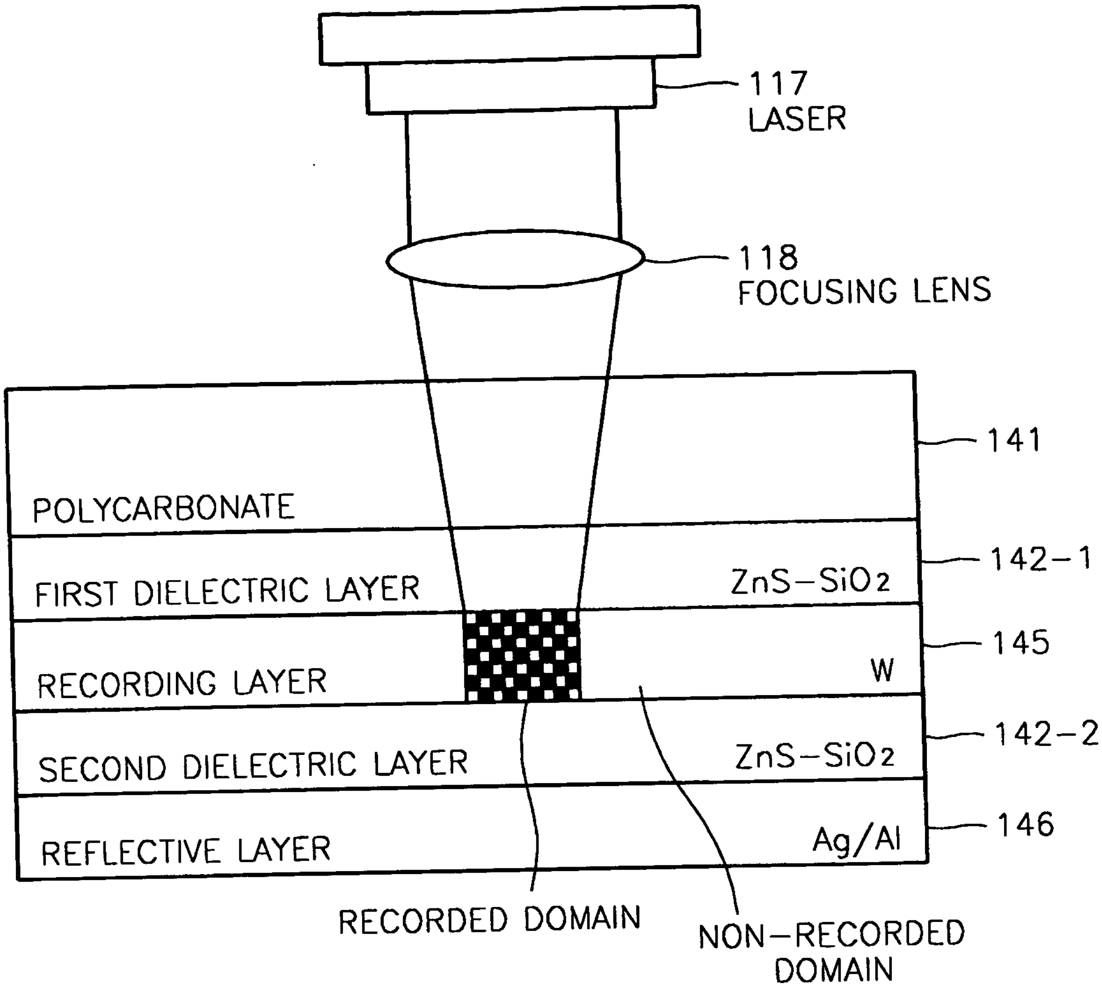
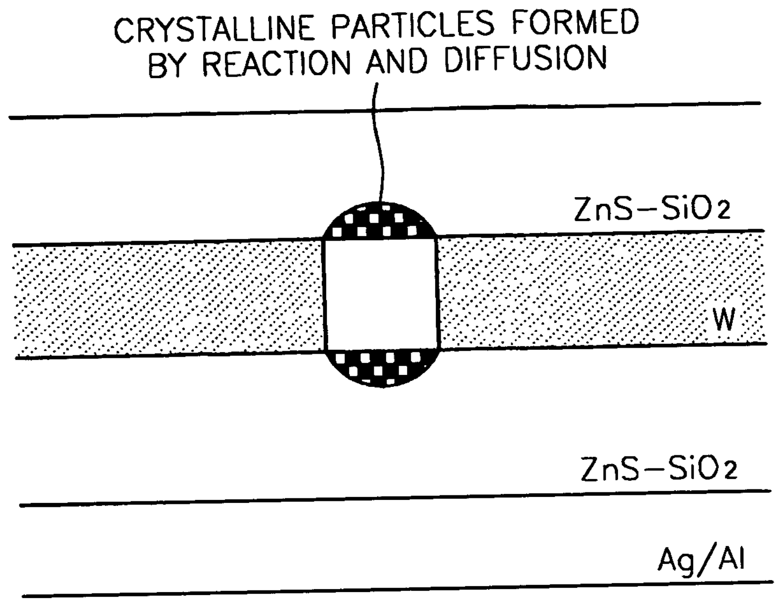
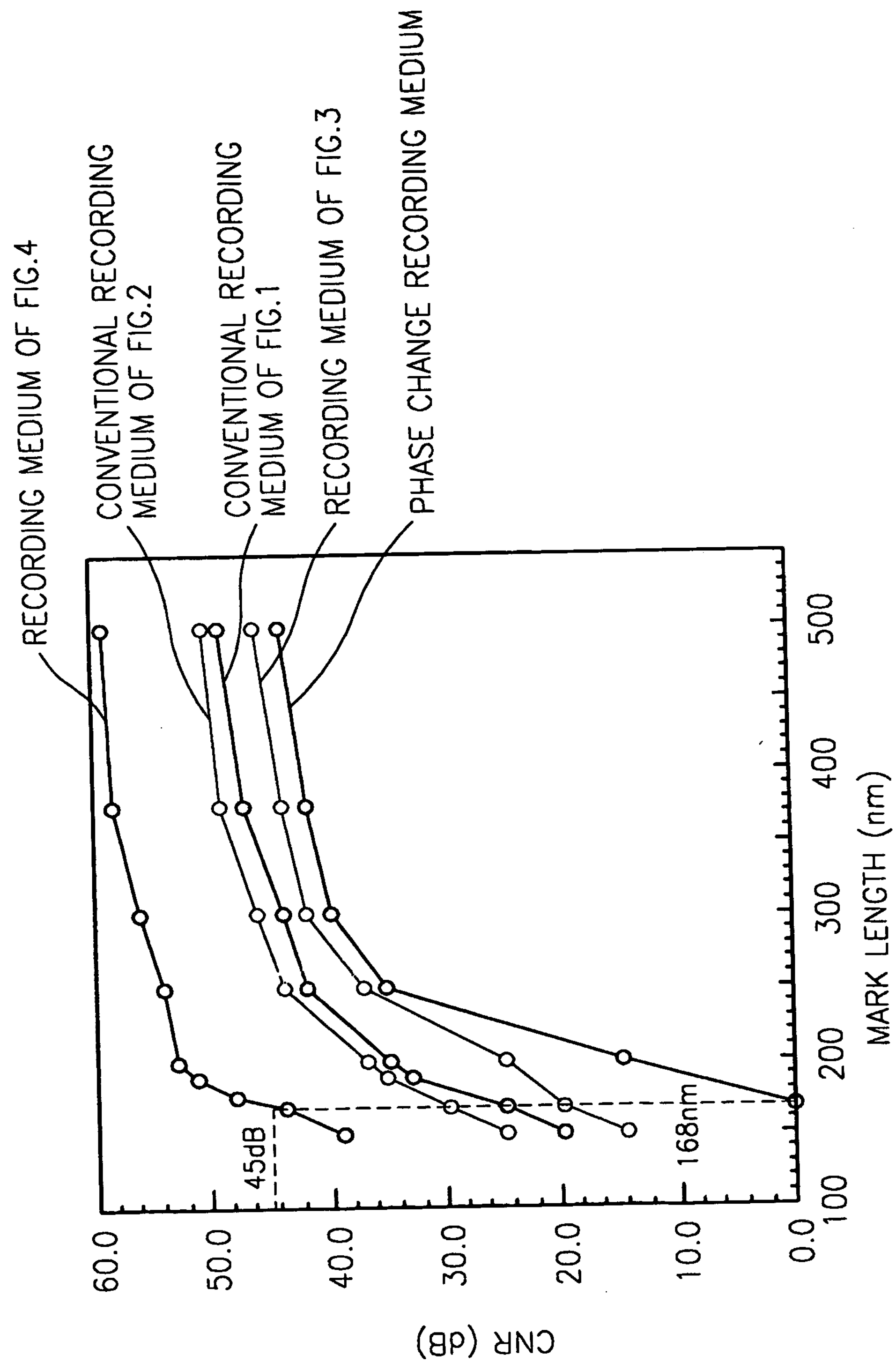

117
LASER
118
FOCUSING LENS
141
POLYCARBONATE
142-1
FIRST DIELECTRIC LAYER
ZnS-SiO2
145
RECORDING LAYER
W
142-2
SECOND DIELECTRIC LAYER
ZnS-SiO2
146
REFLECTIVE LAYER
Ag/Al
RECORDED DOMAIN
NON-RECORDED DOMAIN

FIG. 4B


CRYSTALLINE PARTICLES FORMED BY REACTION AND DIFFUSION
ZnS−SiO2
W
ZnS−SiO2
Ag/Al

6/6

FIG. 5


RECORDING MEDIUM OF FIG.4
CONVENTIONAL RECORDING MEDIUM OF FIG.2
CONVENTIONAL RECORDING MEDIUM OF FIG.1
RECORDING MEDIUM OF FIG.3
PHASE CHANGE RECORDING MEDIUM
45dB
168nm
CNR (dB)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
100
200
300
400
500
MARK LENGTH (nm)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR03/00968

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 G11B 7/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G11B,

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

KR, JP : IPC above

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)

"record*", "medium", "material", "melt*", "dielectric", "plasmon", "sputtering"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR P1999-186525 B1 (LG Ele. Ltd.) 15 APRIL 1999 See the claim 1	1
X	JP P2002-190112 A (TDK CORP.) 5 JULY 2002 See the whole document	4, 5, 10, 11, 16, 17, 22, 23
Y	"	1 ~3, 6, 7~9, 12, 13~15, 18, 19~21, 24
Y	KR P1999-215790 B1 (LG Ele. Ltd.) 26 MAY 1999 See page2. line 55 - 57; Figure 1	2, 8, 14, 20
Y	WO 98/04043 (MATSUSHITA Elec. Ind. Co., Ltd.) 5 MAY 1989 See page 4. line 2 -9	6, 12, 13, 18, 19, 24
Y	KR P2000-247073 B1 (SAMSUNG Ele. Ltd.) 15 MARCH 2000 See page2. line 42 - 53; Claims 1 - 4; Figures 1 - 2	1, 3, 6, 7, 9, 12, 13, 15, 18, 19, 21, 24

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 SEPTEMBER 2003 (01.09.2003)	02 SEPTEMBER 2003 (02.09.2003)

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	JANG, Hyun Sook Telephone No. 82-42-481-5404

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR03/00968

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR P1999-186543 B1 (LG Ele. Ltd.) 15 APRIL 1999 See page2. line 36 - 40; Figure 1	1, 4, 7, 10, 13, 16, 19, 22